PROCEDURE

Using an Inclined Plane

1. Set up a stack of books as shown in Figures 1.

2. Get a board and set up an inclined plane as shown in Figures 1. Measure the length of the board (in meters) and record this value in the data table. Measure and record the height of the inclined plane (in meters).

3. Get a wooden block with a hook on one end. Partly straighten a paper clip—leaving a hook at each end. Use the paper clip to attach the wooden block to your Force Sensor.

4. Connect the Force Sensor to Channel 1 of the LabPro interface. If you are using a Dual-Range Force Sensor, set the range switch to 10N. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.

5. Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap [New] to reset the program.

6. Set up the handheld and interface for the correct Force Sensor.

   a. If the handheld displays FORCE(N) in CH 1, proceed directly to Step 7. If it does not, continue with this step to set up your sensor manually.
   b. On the Main screen, tap [Setup].
   c. On the Setup screen, tap [CH1:].
   d. Choose FORCE-DFS (10N) from the list of sensors.
   e. Tap [OK] to return to the Main screen.

7. Slowly pull the wooden block up the inclined plane. The Force Sensor should be held parallel to, and about 2 cm above, the surface of the inclined plane, as shown in Figure 1. Once the wooden block is moving at a steady rate, tap [Start] to begin data collection. Continue pulling the wooden block until data collection is complete (5.0 seconds).

8. Determine the mean (average) force (in N).

   a. After data collection stops, tap [Analyze].
   b. Tap [Stats].
   c. Record the Mean (average) force (in N).
   d. Tap [OK] twice to return to the Graph screen.

Without an Inclined Plane

9. Now determine the force needed to lift the wooden block.

   a. Repeat Step 7 as you slowly lift the block the same height as the inclined plane.
   b. Repeat Step 8 and record the value of the force (in N) needed to lift the wooden block.

DATA TABLE

Length of inclined plane	___________ m
Height of inclined plane	___________ m
Force (average) to pull the block up the inclined plane	___________ N
Force (average) to lift the block	___________ N

PROCESSING THE DATA

1. Does it take more or less force to move the block using the inclined plane? Explain.

2. A formula for calculating work is

   $$W = F \times d$$

   where W = work (in N•m), F = force (in N), and d = distance (in m). Use this formula to calculate work done using the inclined plane. Here, F = the average force needed to pull the block up the inclined plane and d = the **length** of the inclined plane.

3. Calculate work done in lifting the block. Here, F = the average force needed to lift the block and d = the **height** of the inclined plane.

4. Does it take more or less work to move the block using the inclined plane?

5. A formula for calculating the efficiency of a machine is

$$\text{efficiency} = \frac{\text{work output}}{\text{work input}} \times 100$$

   Use this formula to calculate the efficiency of the inclined plane. Here, work output = the work done lifting the block, and work input = the work done pulling the block up the inclined plane.

6. What causes the difference between the work needed to pull the block up the inclined plane and the work to lift it to the same height? Discuss ways to decrease this difference.

EXTENSIONS

1. Study how changing the inclined plane slope changes force.
2. Design an experiment to study your answer to Question 6.
3. Determine the mechanical advantage of the inclined plane.

Experiment
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TEACHER INFORMATION

An Inclined Plane

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. We suggest that you include one of the extension ideas in the required part of this experiment.

3. The smooth-surface boards used for the inclined plane should be at least 0.5 m long. We use boards that are 1.2 × 0.25 m.

4. A 5 cm × 10 cm × 15 cm piece of wood works well. Insert a hook in the center of one end. Other flat-surface objects can be substituted.

5. The Dual-Range Force Sensor has a low range, –10 to 10 N, and a high range, –50 to +50 N. Students will use the low range for this experiment.

6. For even better results, you can have students *zero* the Force Sensor. They should position their Force Sensor horizontally on the inclined plane, as shown in Figure 1 of the student procedure.

7. Illustrate proper technique for pulling an object up an inclined plane with the force sensor before the experiment. Remind your students not to pull the object too fast.

8. Your students should get better results using the Force Sensor and average force values than with spring scales.

SAMPLE RESULTS

Length of inclined plane	xxxx m
Height of inclined plane	xxxx m
Force (average) to pull object	xxxx N
Force (average) to lift object	xxxx N

ANSWERS TO QUESTIONS

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.